OUTLINE SHEET 3-3-1
Pumps

A. Introduction

Pumps are used to move fluids throughout the engineering spaces. This lesson will help you be familiar with the basic types of pumps and how they work.

B. Enabling Objectives

3.1 **DESCRIBE** the operating principle of basic types of pumps.

3.2 **IDENTIFY** the component parts and functions of basic types of pumps.

C. Topic Outline

1. Introduction
2. Overview
3. Centrifugal Pump
4. Rotary Pump
5. Reciprocating Pump
6. Jet Pump
7. Summary and Review
8. Assignment

ASSIGNMENT SHEET 3-3-2
Pumps

A. Introduction

This material is to be completed prior to the material being covered in class.

B. Enabling Objectives

Refer to enabling objectives in Outline Sheet 3-1-1.

C. Study Assignment

1. Read Fireman NAVEDTRA 12001, pages 9-1 to 9-10.
2. Read Information Sheet 3-1-3

D. Study Questions

1. In your own words, define the following terms:
   a. positive displacement pump
   b. self-priming pump
2. What is the purpose of a lantern ring?
3. What keeps a centrifugal pump from overheating during low flow conditions?
4. How does a jet pump create a low pressure area (vacuum)?

INFORMATION SHEET 3-3-3
Pumps

A. Introduction

This information describes the basic types of pumps used onboard U. S. Navy ships.

B. Reference

Fireman NAVEDTRA 12001
Machinist's Mate 3&2 NAVEDTRA 12144

C. Information

I. Pumps are used to move any substance which flows or which can be made to flow. Examples are water, oil, gases, sludge, and mud.
   A. A pump is a device that uses an external source of power to move a fluid from one place to another.
   B. Every pump has a power end. Examples are steam turbines, steam jets, diesel engine and electric motors.
   C. Every pump has a fluid end where the fluid being pumped enters through the suction and leaves the pump through the discharge.

II. Centrifugal Pump
   A. A centrifugal pump is considered a non-positive displacement pump because the volume of the liquid being discharged from the pump changes whenever:
      1. the weight of the liquid being pumped changes.
         a) The pressure at the bottom of a liquid container depends on the liquid level.
         b) Higher liquid levels exert more weight to the bottom of the container.
         c) The weight of the liquid at the suction of the pump will help push the liquid through while the weight of the liquid at the discharge side will oppose it.
      2. fluid friction increases or decreases.
         a) Fluid friction opposes the flow of fluid.
         b) Higher pump speed resulting in higher flow rate will cause an increase in fluid friction.
      3. obstruction to flow changes.
         a) Any restriction at the discharge side of the pump, such as throttling down on the discharge valve will cause the flow to decrease.
   B. Centrifugal pumps are non-self priming.
      1. Priming a pump means filling the pump with liquid and expelling the air to prepare the pump for operation.

2. Centrifugal pumps are normally located below the level of the liquid being pumped.
3. Gravity creates a static head that keeps the pump primed.
4. Air is expelled through the use of the vent line.

C. Centrifugal pumps are widely used onboard ships for pumping non-viscous liquids such as water.
1. A centrifugal pump uses the throwing force of a rapidly revolving impeller.
2. The liquid is pulled in at the center or eye of the impeller and is discharged through the outer rim.
3. The liquid acquires considerable velocity by the time it reaches the outer rim of the impeller.
4. The liquid is then slowed down by being led into the volute or through a series of diffusing passages. It transforms the energy of the moving liquid from low pressure, high velocity to high pressure, low velocity.

D. The two most common types of centrifugal pumps are the volute pump and the diffuser pump.
1. In the volute pump, the impeller discharges into the volute. The volute is a gradually widening spiral channel in the pump casing.
2. In the diffuser pump, the impeller discharges into the stationary diffuser vanes. These vanes slow down the liquid before allowing it into the volute.

E. The impeller of the centrifugal pump rotates at high speed.
1. The impeller is machined to maintain a close clearance between the hub of the impeller and the part of the casing in which the hub rotates.
2. The purpose of the close clearance is to minimize leakage from the discharge side of the pump casing to the suction side.
3. Due to this close clearance, the hub of the impeller and the part of the casing in which the hub rotates are subject to rapid wear.
4. To eliminate the need to replace the entire impeller and pump casing solely due to wear at this location, most pumps are designed with replaceable wearing rings.
    a) The impeller wearing ring is attached to the hub and rotates with the impeller.
    b) The casing wearing ring is attached to the pump casing and is stationary.

F. Stuffing boxes or mechanical seals are used to seal the shaft against the casing.
1. The stuffing box contains rings of packing.
2. Seal pipings, used to cool, lubricate, and seal the shaft and the packing are installed in some pumps.

3. A lantern ring is inserted between the rings of the packing so that water can flow between the shaft and the packing.

G. The part of the shaft in contact with the packing will become grooved due to friction. A replaceable shaft sleeve is used in this area because it is cheaper to replace the sleeve rather than replace the whole shaft.

H. Mechanical seals are used instead of packing in various pumps.
1. On one type of mechanical seal, spring pressure keeps the rotating seal face snug against the stationary seal face. The system pressure inside the pump also helps to keep the rotating seal face tight against the stationary seal face.
2. The rotating seal face is attached to the shaft.
3. The stationary seal face is held in place by the seal gland and packing ring.

I. Recirculating lines are installed on centrifugal pumps to prevent them from overheating and becoming vapor bound.
1. A recirculating line is a small line connecting the discharge side with the suction side of the pump.
2. This allows water to recirculate, thus maintaining a flow of liquid through the pump.

J. Reverse flow through the pump is prevented through the use of a check valve.

K. Summary of operation of the centrifugal pump:
1. Liquid enters the suction side of the casing and into the eye of the impeller.
2. The rotating impeller throws the liquid against the casing by centrifugal force.
3. When the liquid is thrown outward against the casing, a region of low pressure is created at the eye of the impeller.
4. More liquid moves into the eye of the impeller to replace the liquid being thrown out.
5. The liquid moving between the blades of the impeller will spread out causing it to lose velocity and increase in pressure.
6. Depending on the type of centrifugal pump, the liquid may pass through the diffuser or go straight to the volute, which slows down and collects the liquid and channels it to the discharge piping.

III. Rotary Pumps

A. Rotary pumps are positive displacement pumps.
1. A fixed volume of fluid is discharged by the pump with each revolution, regardless of the head pressure.
2. Blockage in the system can quickly cause damage to the pump or rupture in the system piping.
3. Rotary pumps require a relief valve at the discharge side to protect the pump and the piping system.

4. Rotary pumps are useful for pumping oil and other heavy viscous fluid.

B. Rotary pumps are self-priming.
   1. The tight clearance between the rotating element and the casing allows air to be pumped and expelled,
   2. This creates a low pressure area on the suction side that draws the liquid to replace the air being pumped out.

C. The classification of rotary pumps is generally based on the type of rotating element.
   1. The simple gear pump has two spur gears that mesh together and revolve in opposite directions.
      a) One gear is called the driving gear while the other is the driven gear.
      b) The liquid is trapped and carried along in the pockets formed by the gear teeth and the pump casing.
      c) Because of the meshing of the gears, the liquid does not have any place to go but through the discharge side of the pump.
   2. In the screw pump, the liquid is trapped and forced through the pump by the action of the rotating screws.
      a) As the rotor turns, the liquid flows in between the threads at the outer end of each pair of screws.
      b) The treads carry the liquid along within the housing to the center of the pump where it is discharged.
      c) In the double-screw low pitch pump, one rotor is driven by the drive shaft while the other is driven by a set of timing gears.
      d) In the triple-screw, high pitch pump, a central rotor meshes with two idler rotors.
      e) Most screw pumps are equipped with mechanical seals. In case of mechanical seal failure, the stuffing box may accept rings of conventional packing for emergency use.
   3. In the sliding vane pump, the liquid is trapped in the pocket formed by the rotor, sliding vane, and cylinder wall.
      a) The sliding vanes come in and out of the rotor as it rotates. The rotor is eccentrically located in relation to the casing.
      b) The vane comes out as it passes through the suction side, trapping the liquid as it rotates.
      c) The vane is pushed in as it is passes through the discharge side to expel the fluid.

4. A reciprocating pump moves water or other liquid by the use of a plunger or piston that travels back and forth inside a cylinder.
    a) Reciprocating pumps are self-priming, positive displacement pumps. Each stroke of the pump will displace a definite quantity of liquid regardless of the resistance against which the pump is operating.
    b) A single-acting reciprocating pump draws liquid into its cylinder on the suction stroke and forces the liquid out on the discharge stroke.
    c) A double-acting reciprocating pump draws or discharges liquid on both ends of the piston.

IV. Jet Pumps
- A. Jet pumps have no moving parts.
- B. Some jet pumps are used for pumping large quantities of liquid.
    1. The kind most often used is the eductor, which is used to pump bilges and dewater compartments.
    2. Eductors use a high-velocity jet of seawater to lower the pressure in the chamber around the converging nozzle.
        a) Seawater exits the converging nozzle at a high velocity.
        b) As the seawater passes through the chamber, air becomes entrained in the jet stream and is pumped out of the chamber.
        c) Pressure in the chamber decreases, drawing more water from the suction line.
        d) The diverging nozzle allows the velocity of the fluid to decrease and the pressure to increase.
- C. The jet pump is a self-priming, non-positive displacement pump.
    1. It is able to pump air out.
    2. The volume of its discharge depends on the head pressure.